

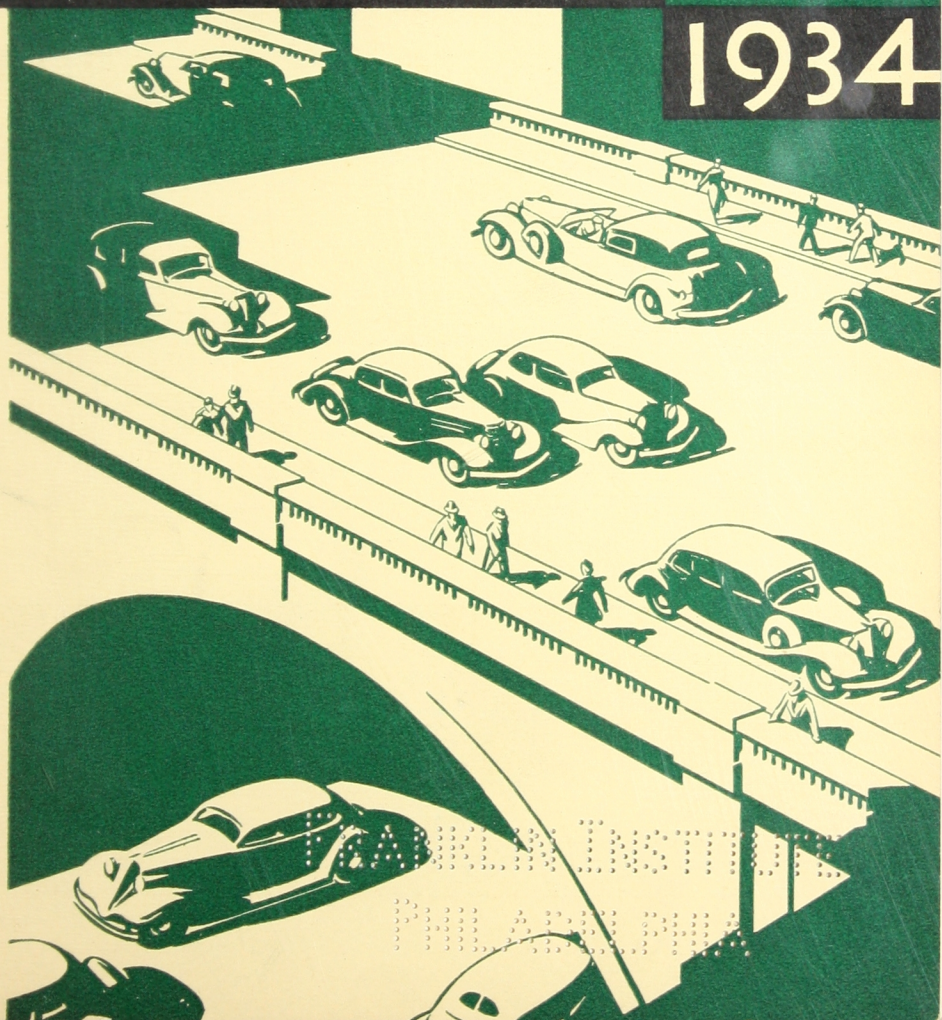
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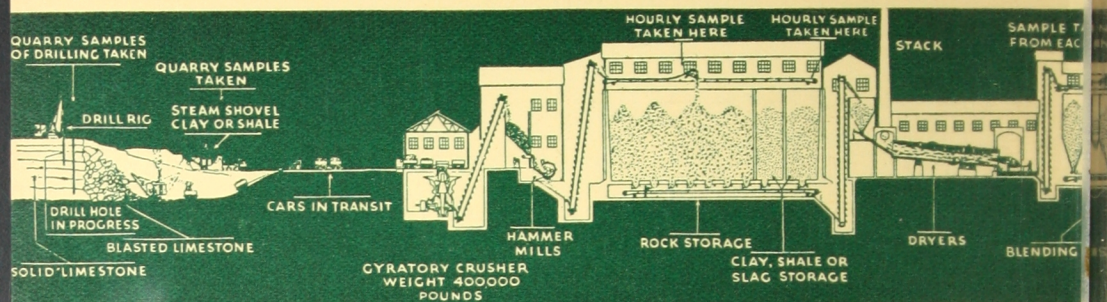
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CEMENT & CONCRETE

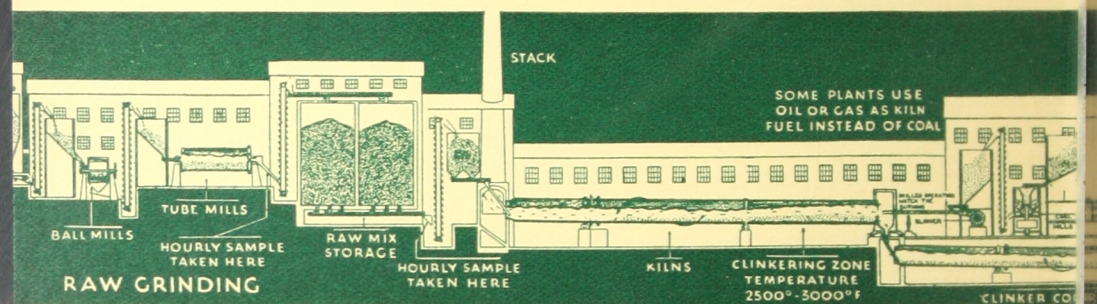
REFERENCE BOOK

1934

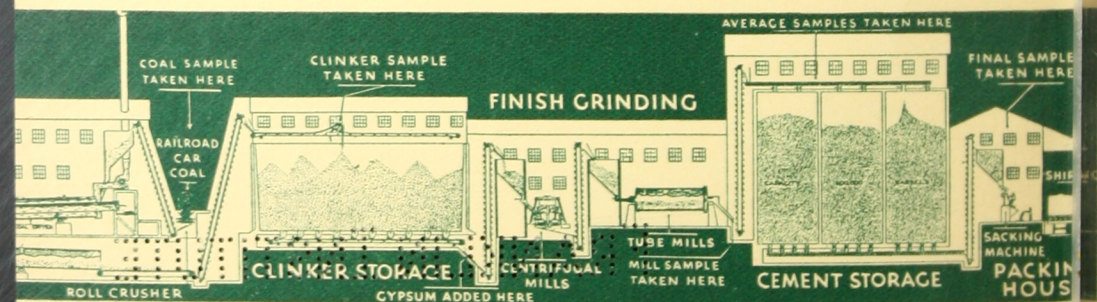




Here is pictured the process required to change clay, rock and other raw materials into portland cement—the most versatile and enduring of modern building materials. Cement is the active ingredient in concrete, stucco and mortar, which have more than a thousand common uses in the construction field, providing safe, economical roads



—bridges—dams—buildings—indispensable to the well-being of every American. Although more than eighty steps are required to make cement, it is sold at a factory price of a fraction of a cent a pound—less we are told, than that of any other manufactured product.



AMERICAN

CEMENT and CONCRETE REFERENCE BOOK

—1934—

PORTLAND CEMENT ASSOCIATION

A National Organization to Improve and Extend the Uses of Concrete

33 WEST GRAND AVENUE • CHICAGO

•

DISTRICT OFFICES

Atlanta, Ga.

Austin, Texas

Columbus, Ohio

Des Moines, Iowa

Indianapolis, Ind.

Kansas City, Mo.

Lansing, Mich.

Lincoln, Neb.

Los Angeles, Cal.

Minneapolis, Minn.

New York, N. Y.

Oklahoma City, Okla.

Philadelphia, Pa.

Pittsburgh, Pa.

Portland, Ore.

St. Louis, Mo.

San Francisco, Cal.

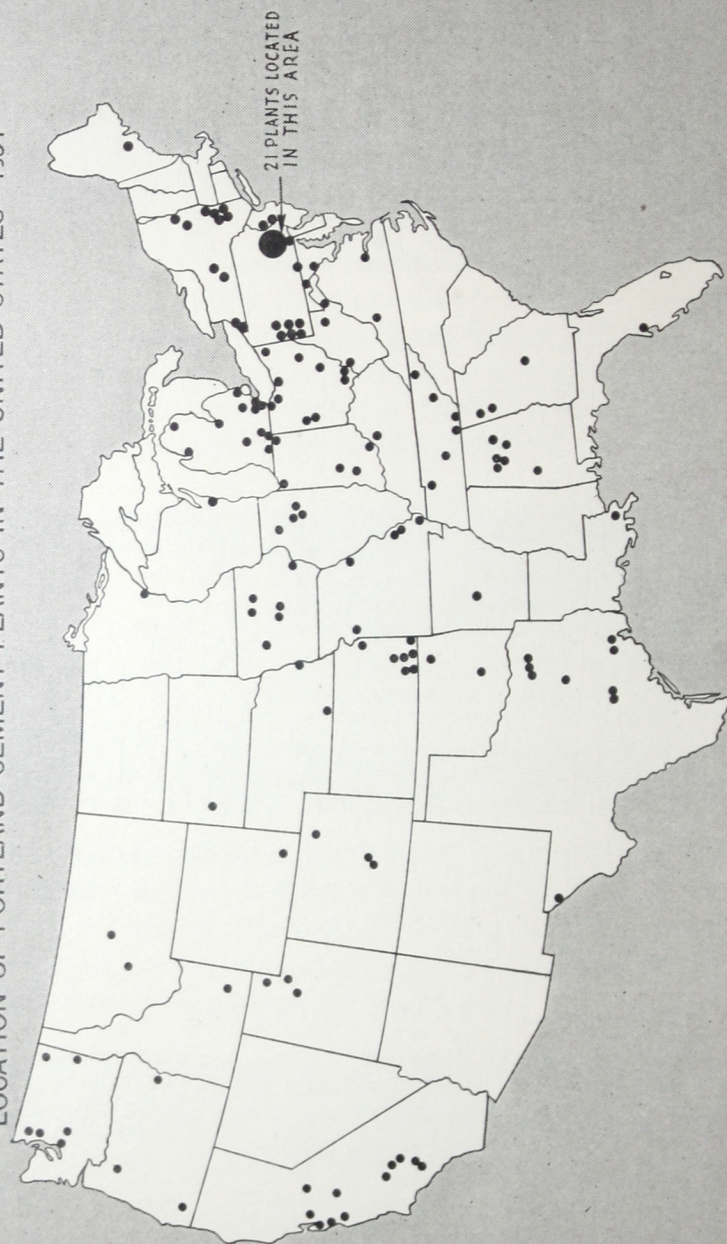
Seattle, Wash.

Spokane, Wash.

Washington, D. C.

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LOCATION OF PORTLAND CEMENT PLANTS IN THE UNITED STATES—1934



GROWTH OF PORTLAND CEMENT INDUSTRY IN AMERICA

IN 1824, Joseph Aspdin, a brick-layer of Leeds, England, sought a better bond for his masonry. He combined certain quantities of lime and clay, burned them in a kiln, pulverized the resulting mass and used it to make mortar and concrete. The concrete so resembled the stone quarried on the Isle of Portland that Aspdin called his base material "portland" cement and patented it.

Until the first portland cement was made in this country in 1872 by David O. Saylor in the Lehigh Valley district of Pennsylvania, all portland cement was imported from Europe. Even after Saylor had proved that American made cement was as good as the European product, builders continued for many years to use foreign cement in large quantities.

Saylor, a maker of natural cements, began his experiments with portland cement by burning rocks in his own kitchen. John K. Shinn, another Pennsylvanian, also made cement with makeshift machinery. Thomas Millen, a concrete pipe maker, decided \$9.12 a barrel was too much to pay for portland cement and opened his own mill in Indiana in 1876.

Foreign portland cement and domestic natural cement were long competitors of the American made portlands, and it was not until 1897 that the use of American cement

exceeded importations from Europe. In 1890, sixteen plants produced 335,500 barrels of portland cement against 7,082,000 barrels of natural cement and imports of 1,940,186 barrels of foreign portland cement. Ten years later, native portland cement production was 8,482,020 barrels. Imports were declining rapidly and domestic natural cement production was falling off to a great extent.

Now, with a yearly capacity of more than two barrels for each individual, American cement mills produce and the nation uses more cement than any other country in the world, and in normal times almost as much as all the rest of the world combined. The commodity, little resembling Aspdin's early discovery, has been developed into a superior, highly standardized product.

With a total capital investment exceeding \$576,000,000, there are now 166 cement mills in the United States capable of producing 269,000,000 barrels a year. Production in 1933, due to stagnant conditions throughout the construction industry, totaled less than 64,000,000 barrels.

Portland cement is made in 35 states, the largest producers being Pennsylvania, California, New York, Illinois, Missouri, Michigan and Iowa. The map on page 2 shows locations of these plants.

The Portland Cement Industry in the United States

(Based on 1933 figures of the U. S. Bureau of Mines and other authoritative sources)

	1933
Production (Barrels)	63,473,189
Value of Product*	\$84,419,341
Number of Operating Companies	93
Number of Plants	166
Number of States Represented	35
Estimated Capacity (Barrels)	269,387,000
Per Cent of Capacity Utilized	23.6
Total Capital Invested	\$576,000,000
Investment per Barrel of Capacity	\$2.14
Number of Wage Earners	20,000
Plant Investment per Worker	\$28,800
Wages and Salaries	\$18,279,000
Cost of Materials and Supplies	\$26,932,000
Per Capita Consumption, U. S. (Barrels)	0.50

*Based on average factory value per barrel in bulk reported by U. S. Bureau of Mines.

Materials Required Annually for the Manufacture of Portland Cement

(Figures based on 1933 production, U. S. Bureau of Mines' and Manufacturers' estimates)

Coal, tons	3,000,000
Fuel oil, barrels	1,620,000
Natural gas, cubic feet	22,000,000,000
Cloth sacks required in stock	48,600,000
Cloth sacks for replacements	10,800,000
Paper bags	72,000,000
Wire to tie sacks, miles	17,000
Lubricants (oil and grease), pounds	12,300,000
Belting, miles	72
Explosive, pounds	8,300,000
Gypsum, tons	350,000
Fire-brick for kiln lining, brick	2,050,000

More than 600 lb. of raw materials are needed to make a single barrel of cement weighing 376 lb. In addition, some 110 lb. of coal or equivalent fuel are required to pro-

duce each barrel of portland cement.

The cement industry is the largest user of pulverized coal, practically all that noted in the table at the left being pulverized and burned in the kilns. This estimate does not include coal required to produce power purchased from outside generating stations.

The industry ranks as one of the highest among all industries in total horsepower required to operate its grinding and other machinery. The power installation needed for a single large cement plant produces enough electricity to supply a city of 150,000 population with power and light.

Production of Principal Cement-Producing States

(As Reported by U. S. Bureau of Mines)

State	Active Plants		Barrels		Increase or De- crease, 1933	Rank in Total Produc- tion
	1932	1933	1932	1933		
Alabama.....	6	6	1,453,374	1,968,513	+35	11
California.....	11	11	5,481,942	7,165,430	+31	2
Illinois.....	4	4	5,480,813	3,973,853	-27	4
Iowa.....	5	5	4,270,739	3,044,008	-29	7
Kansas.....	7	6	2,295,541	2,201,182	-4	10
Michigan.....	13	10	4,295,610	3,632,843	-15	6
Missouri.....	5	5	4,238,461	3,798,662	-10	5
New York.....	10	10	6,013,582	4,204,730	-30	3
Ohio.....	10	10	4,002,123	2,781,008	-31	9
Pennsylvania..	27	24	15,798,724	12,294,374	-22	1
Tennessee.....	6	6	1,546,569	1,347,528	-13	12
Texas.....	9	9	3,748,167	2,970,070	-21	8
Other States..	47	46	18,115,300	14,090,988	-22	.....
Total.....	160	152	76,740,945	63,473,189	-17	

Cement Industry Is Important Railroad Shipper of Manufactured Products

[Figures from latest records (1930) on file at the
Interstate Commerce Commission, Washington]

Rank	Carloads
1. Petroleum oils, refined, and all other gasolines.....	1,608,363
2. Iron and steel, rated 5th in official classification, N.O.S. (Also tin and terneplate)	821,757
3. Cement.....	590,725
4. Automobiles (passenger)	352,397
5. Fertilizers, N.O.S.	461,390
6. Fuel oil, road and petroleum residual oils, N.O.S.	328,956
7. Scrap iron and scrap steel.	248,310
8. Brick, N.O.S., and building tile	211,914
9. Automobiles and autotrucks, K.D. and parts, N.O.S.	205,777
10. Brick, common	111,605
11. Canned food products, N.O.S.	203,416
12. Machinery and boilers	167,896
13. Lubricating oils and greases.	160,377
14. Iron and steel pipe and fittings, N.O.S.	158,395

N.O.S.—Not otherwise specified.

K.D.—Knocked down.

THE PORTLAND CEMENT INDUSTRY IN

(Figures from U. S. Geological Survey and
U. S. Bureau of Mines)

Year	Production (Barrels)	No. of Producing Plants (a)	Estimated Capacity (Barrels)	Per Cent of Capacity Utilized (b)	Value of Product	Av. Fac- tory Value per Barrel in Bulk
1870-79	82,000	.	.	.	\$ 246,000	\$3.00 (d)
1880	42,000	.	.	.	126,000	3.00 (d)
1890	335,500	16	.	.	704,050	2.09
1895	990,324	22	.	.	1,586,830	1.60
1900	8,482,020	50	.	.	9,280,525	1.09
1901	12,711,225	56	.	.	12,532,360	0.99
1902	17,230,644	65	.	.	20,864,078	1.21
1903	22,342,973	78	.	.	27,713,319	1.24
1904	26,505,881	83	.	.	23,355,119	0.88
1905	35,246,812	79	.	.	33,245,867	0.94
1906	46,463,424	84	140,000 (c)	.	52,466,186	1.13
1907	48,785,390	94	55,000,000	88.7	53,992,551	1.11
1908	51,072,612	98	60,000,000	85.1	43,547,679	0.85
1909	64,991,431	108	93,500,000	68.4	52,858,354	0.813
1910	76,549,951	111	97,670,000	78.3	68,205,800	0.891
1911	78,528,637	115	112,500,000	69.8	66,248,817	0.844
1912	82,438,096	110	110,000,000	74.9	67,016,928	0.813
1913	92,097,131	113	115,000,000	80.1	92,557,617	1.005
1914	88,230,170	110	115,000,000	76.7	81,789,368	0.927
1915	85,914,907	106	129,800,000	66.2	73,886,820	0.86
1916	91,521,198	113	133,679,650	68.5	100,947,881	1.103
1917	92,814,202	117	136,750,322	67.9	125,670,430	1.354
1918	71,081,663	114	137,601,200	51.7	113,730,661	1.596
1919	80,777,935	111	134,092,700	60.2	138,130,269	1.71
1920	100,023,245	117	146,400,000	68.3	202,046,955	2.02
1921	98,842,049	115	144,354,000	68.5	186,811,473	1.89
1922	114,789,984	118	146,203,000	78.5	202,030,372	1.76
1923	137,460,238	126	161,858,000	84.9	261,174,452	1.90
1924	149,358,109	132	175,100,000	85.3	270,338,177	1.81
1925	161,658,901	138	193,558,000	83.5	286,136,255	1.77
1926	164,530,170	140	215,300,000	76.4	281,346,591	1.71
1927	173,206,513	153	227,080,000	73.9	280,594,551	1.62
1928	176,298,846	156	243,702,000	72.3	276,789,188	1.57
1929	170,646,036	163	258,917,000	65.9	252,556,133	1.48
1930	161,197,228	163	270,044,000	59.7	232,124,008	1.44
1931	125,429,071	165	271,850,000	46.1	139,226,268	1.11
1932	76,740,945	166	271,308,000	28.3	77,508,354	1.01
1933	63,473,189	166	269,387,000	23.6	84,419,341	1.33

(a) Number of plants active during year from 1905 on; previously, number of existing works.

(b) Ratio of finished portland cement produced to manufacturing capacity.

(c) Estimated daily capacity; annual not computed.

(d) 1870-1880.

THE UNITED STATES—1870 TO 1933, INCLUSIVE

(Figures from U. S. Geological Survey and
U. S. Bureau of Mines)

Per Capita Consump- tion U. S. (e)	Ship- ments (Barrels)	Stocks on Hand at End of Year (Barrels)	Imports of Hydraulic Cement (Barrels) (f)	Exports of Hydraulic Cement (Barrels) (h)	Year
...	...	...	198,000 (g)	507,077 (i)	1870-79
...	...	...	187,000	41,989 (i)	1880
...	...	...	1,940,186	86,963 (i)	1890
...	...	...	2,997,395	83,682	1895
...	...	...	2,386,683	100,400	1900
...	...	...	939,330	373,934	1901
...	...	...	1,963,023	340,821	1902
...	...	...	2,251,969	285,463	1903
...	...	...	968,409	774,940	1904
...	...	...	896,845	897,686	1905
...	...	...	2,273,493	583,299	1906
...	...	...	2,033,438	900,550	1907
...	...	...	842,121	846,528	1908
...	...	...	433,888	1,056,922	1909
...	...	...	306,863	2,475,957	1910
...	75,547,829	10,385,789	164,670	3,135,409	1911
...	85,012,556	7,811,329	68,503	4,215,532	1912
...	88,689,377	11,220,328	85,470	2,964,358	1913
0.77	86,437,956	12,773,463	120,906	2,140,197	1914
0.83	86,891,681	11,462,523	42,218	2,565,031	1915
0.89	94,552,296	8,360,552	1,836	2,563,976	1916
0.84	90,703,474	10,353,838	2,323	2,586,215	1917
0.64	70,915,508	10,451,044	305	2,252,446	1918
0.77	85,612,899	5,256,900	8,931	2,463,573	1919
0.87	96,311,719	8,833,067	524,604	2,985,807	1920
0.87	95,507,147	12,192,567	122,317	1,181,014	1921
1.06	117,701,216	9,352,250	355,931	1,127,845	1922
1.21	135,912,118	10,812,639	1,767,264	1,001,688	1923
1.29	146,047,549	14,151,695	2,023,663	678,543	1924
1.38	157,295,212	18,336,173	3,667,458	1,019,597	1925
1.37	162,187,090	20,740,187	3,244,223	974,326	1926
1.44	171,864,728	22,457,382	2,065,730	816,726	1927
1.45	175,838,332	22,917,896	2,284,085	824,656	1928
1.41	169,868,322	23,537,817	1,745,345	855,321	1929
1.29	159,059,334	25,848,000	984,807	755,778	1930
1.06	127,150,534	23,942,000	457,238	429,653	1931
0.67	80,843,187	20,351,058	462,496	374,581	1932
0.50	64,282,756	19,541,491	477,794	680,301	1933

(e) Based on shipments of domestic portland cement from mills into states.

(f) Hydraulic cement imported for consumption; bbl. of 376 lb. in 1920 to 1933 and 380 lb. in earlier years.

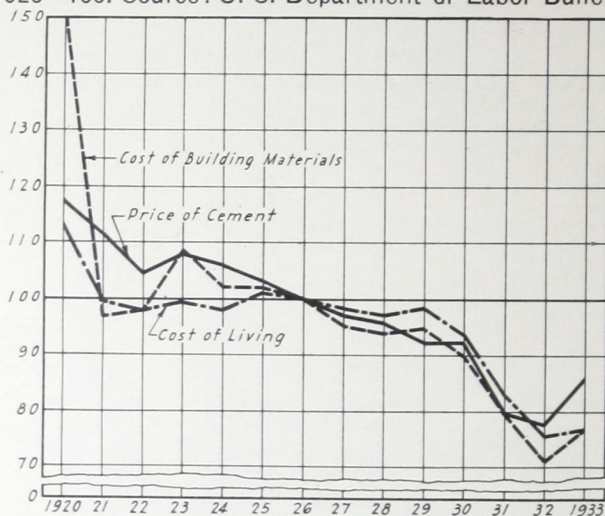
(g) Imports in 1878 and 1879.

(h) Hydraulic cement exported from the United States.

(i) Lime and cement of domestic production exported from United States.

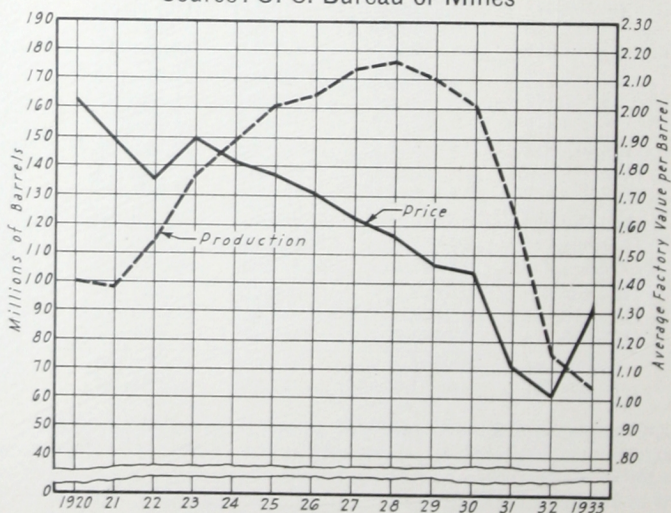
PORTLAND CEMENT PRICES COMPARED WITH BUILDING MATERIAL PRICES AND LIVING COSTS

Index 1926 = 100. Source: U. S. Department of Labor Bulletin R-73



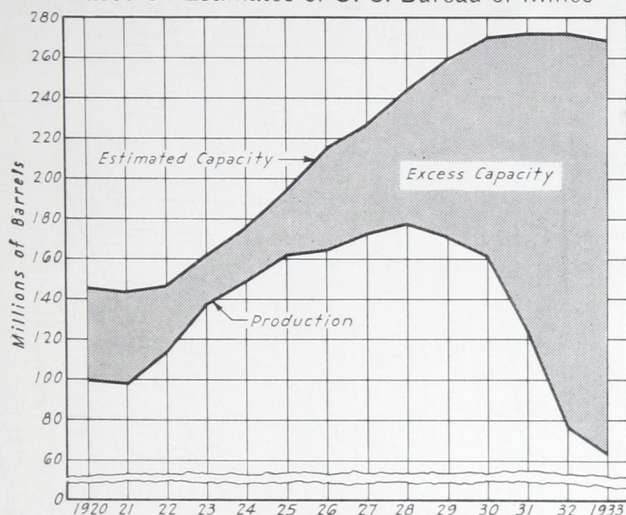
PRODUCTION AND PRICE OF CEMENT

Source: U. S. Bureau of Mines



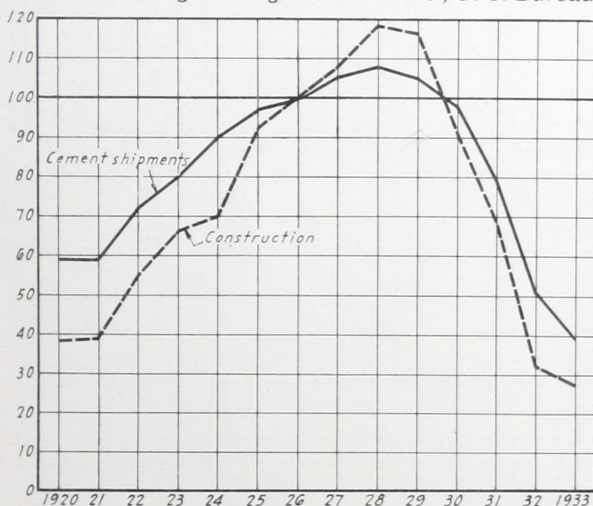
PRODUCTION AND CAPACITY

Based on Estimates of U. S. Bureau of Mines



CEMENT SHIPMENTS AND VOLUME OF CONSTRUCTION

1926 = 100. Sources: Engineering News-Record; U. S. Bureau of Mines

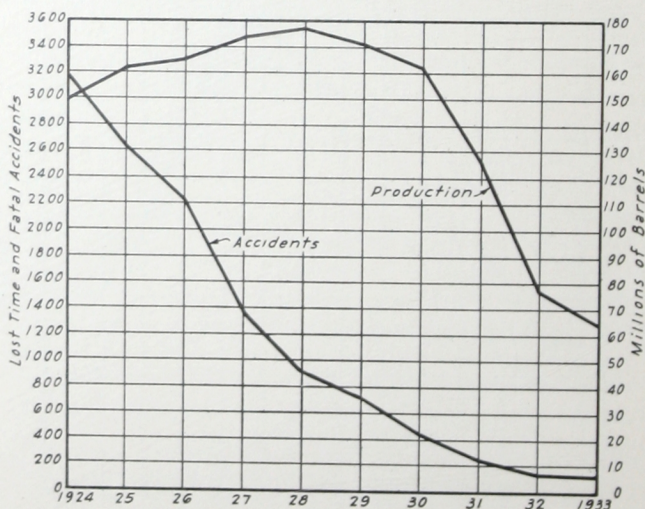


Ten Years of Accident Prevention Progress in the Cement Industry

(Based on records of the Bureau of Accident Prevention and Insurance of the Portland Cement Association, covering accident experience in member company plants in the United States and Canada)

Years	No. of Plants Reporting	Total No. of Lost-Time Accidents	No. of Lost-Time Accidents per Million Man Hrs.	No. of Permanent Disabilities	No. of Fatalities	No. of No-Accident Plants	% of No-Acc. Plants to Total
1924	110	3,098	35.3	76	60	None	0.0
1925	120	2,541	27.0	77	61	2	1.66
1926	124	2,174	22.0	64	45	2	1.61
1927	134	1,337	14.0	66	30	12	8.95
1928	136	877	10.0	74	33	17	12.5
1929	138	686	9.5	55	37	28	20.3
1930	128	420	6.3	48	18	46	35.9
1931	100	197	5.6	27	17	39	39.0
1932	112	125	4.5	16	5	57	50.9
1933	116	120	4.6	23	7	61	52.6

ACCIDENT REDUCTION IN THE CEMENT INDUSTRY
IN RELATION TO PRODUCTION OF CEMENT



USE OF PORTLAND CEMENT PER CAPITA, 1933

State	Use Per Capita, Barrels	Barrels Used in 1933	Rank in Use Per Capita	% Total Used Shipments	Rank in Total Used	Popula- tion (1930)
Alabama . . . . .	.350	926,199	38	1.44	22	2,646,248
Arizona . . . . .	.288	125,512	44	.20	47	435,573
Arkansas . . . . .	.363	673,394	36	1.05	30	1,854,482
California . . . . .	.874	4,966,717	4	7.73	3	5,677,251
Colorado . . . . .	.415	430,248	26	.67	34	1,035,791
Connecticut . . . . .	.458	736,736	22	1.15	26	1,606,903
Delaware	1.058	252,231	3	.39	39	238,380
Florida . . . . .	.407	597,776	29	.93	32	1,468,211
Georgia . . . . .	.250	728,503	46	1.13	27	2,908,506
Idaho . . . . .	.266	118,811	45	.18	48	445,032
Illinois . . . . .	.693	5,295,165	7	8.24	2	7,630,654
Indiana . . . . .	.613	1,986,509	9	3.09	10	3,238,503
Iowa . . . . .	.608	1,502,613	10	2.34	12	2,470,939
Kansas . . . . .	.503	946,388	18	1.47	20	1,880,999
Kentucky . . . . .	.476	1,244,560	21	1.94	17	2,614,589
Louisiana . . . . .	.359	756,252	37	1.18	25	2,101,593
Maine . . . . .	.391	312,182	30	.49	36	797,423
Maryland . . . . .	.511	835,241	16	1.30	24	1,631,526
Massachusetts . . . . .	.346	1,474,000	40	2.29	13	4,249,614
Michigan . . . . .	.509	2,465,262	17	3.84	8	4,842,325
Minnesota . . . . .	.573	1,469,078	12	2.29	14	2,563,954
Mississippi . . . . .	.341	686,650	42	1.07	29	2,009,821
Missouri . . . . .	.702	2,548,680	6	3.96	7	3,629,367
Montana . . . . .	.301	162,318	43	.25	44	537,606
Nebraska . . . . .	.744	1,025,869	5	1.60	18	1,377,963
Nevada	15.761	1,435,214	1	2.23	15	91,058
New Hampshire . . . . .	.562	261,686	14	.41	38	465,293
New Jersey . . . . .	.501	2,026,606	19	3.15	9	4,041,334
New Mexico . . . . .	.457	193,681	23	.30	43	423,317
New York . . . . .	.570	7,177,654	13	11.17	1	12,588,066
North Carolina . . . . .	.153	484,405	48	.75	33	3,170,276
North Dakota . . . . .	.194	132,761	47	.21	46	680,845
Ohio . . . . .	.411	2,738,270	27	4.26	6	6,646,697
Oklahoma . . . . .	.590	1,415,678	11	2.20	16	2,396,040
Oregon . . . . .	.346	330,294	41	.51	35	953,786
Pennsylvania . . . . .	.428	4,128,354	25	6.42	4	9,631,350
Rhode Island . . . . .	.410	282,078	28	.44	37	687,497
South Carolina . . . . .	.124	217,155	49	.34	42	1,738,765
South Dakota . . . . .	.347	240,893	39	.37	41	692,849
Tennessee . . . . .	.365	957,390	34	1.49	19	2,616,556
Texas . . . . .	.551	3,211,166	15	5.00	5	5,824,715
Utah . . . . .	.477	242,514	20	.38	40	507,847
Vermont . . . . .	.390	140,289	31	.22	45	359,611
Virginia . . . . .	.380	921,463	32	1.43	23	2,421,851
Washington . . . . .	.439	687,439	24	1.07	28	1,563,396
West Virginia . . . . .	.372	642,998	33	1.00	31	1,728,205
Wisconsin . . . . .	.624	1,836,251	8	2.86	11	2,939,006
Wyoming . . . . .	.365	82,499	35	.13	49	225,565
Washington, D. C.	1.936	942,601	2	1.47	21	486,869

Average 0.50

Estimated Distribution of Uses of Portland Cement in the United States, 1933

(Based on studies of construction figures and other data)

	%	Barrels
Concrete roads, streets, alleys, curbs, gutters and pavement bases	32.0	20,600,000
Structural concrete in buildings of all types	27.0	17,300,000
Rural uses exclusively, including farm structures.	12.0	7,700,000
Concrete products, except products used on farms	3.3	2,100,000
Railways, all uses, including street railways.	8.0	5,100,000
Sewerage, drainage, culverts, and specialties.	6.5	4,100,000
Sidewalks and private driveways (exclusive of rural)	3.0	1,900,000
Bridges, river and harbor works, dams and water power projects, storage tanks and reservoirs	8.2	5,200,000
Total.	100.0	64,000,000

Modern Highways Developed Through Research

IN no field of public works construction is the taxpayer's dollar more carefully spent than for highways. This is due chiefly to the great amount of study and research which has been carried on by the United States Bureau of Public Roads, state highway departments and highway engineers, to determine proper locations for roads and the most economical pavement.

Research into the serviceability of various types of pavement surfaces has led to important refinements, both in the quality and design of roads. Pioneering in this, Illinois approached its huge highway program by making exhaustive tests to discover the most economical type of pavement.

For this purpose the Bates Experimental Road was constructed near Springfield, Ill., in 1921. In the first tests, a fleet of army trucks with loads of one to ten tons made 23,200 round trips over a series of

63 sections of all types and designs of pavements. Only 13 stood up; ten were all-concrete pavements; of the other three, one had brick and two had asphalt surfaces, all on concrete bases six or more inches thick. After this demonstration of superiority, five new concrete sections were built; given more severe tests, emerged successfully. This is one of the outstanding highway investigations.

Two important design principles were established: first, that a road is no stronger than its base; second, that for the most economical design of rigid pavements, the center thickness should be two-thirds of the edge thickness.

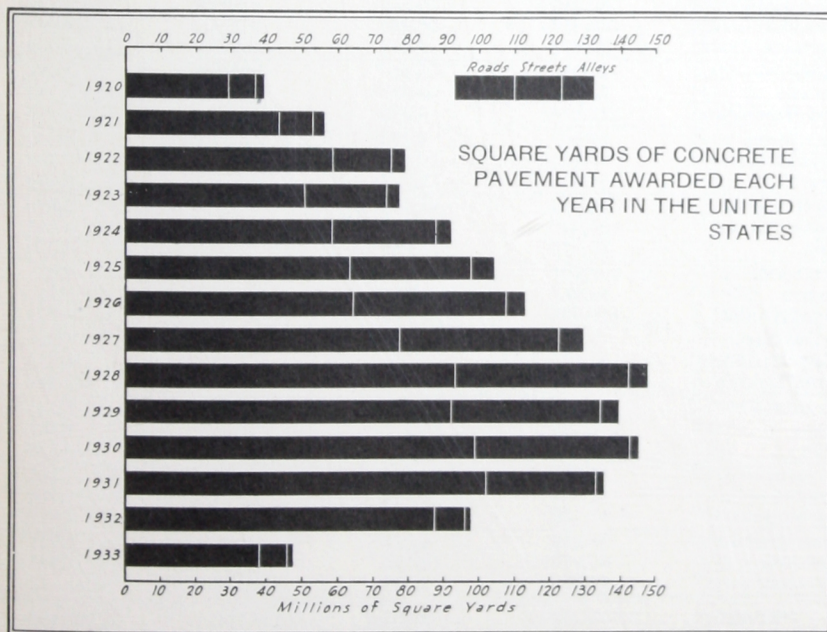
Results of these tests and studies show that the only sound basis for highway design is a detailed knowledge of the character and volume of traffic to be served; and that the economical pavement for any traffic can be accurately designed.

Square Yards of Concrete Pavement Awarded in U. S.

Year	Roads	Streets	Alleys	Total	Total Built†
*1909	66,687	770,022	199,316	1,036,025	—
1910	151,148	682,637	107,874	941,659	—
1911	291,077	1,011,440	136,674	1,439,191	—
1912	1,869,486	3,326,029	185,703	5,381,218	—
1913	3,339,185	3,946,219	308,365	7,593,769	—
1914	10,608,421	4,830,604	300,138	15,739,163	—
1915	12,050,909	5,933,879	612,921	18,597,709	—
1916	15,906,801	7,395,975	880,179	24,182,955	—
1917	15,333,087	5,238,062	1,200,030	21,771,179	—
1918	12,990,519	3,295,817	585,948	16,872,284	—
1919	41,335,342	11,086,419	1,038,173	53,459,934	—
1920	29,326,689	8,814,782	907,164	39,048,635	—
1921	43,862,503	10,695,548	1,606,085	56,164,136	—
1922	58,301,413	18,607,792	2,176,500	79,085,705	—
1923	50,893,999	24,385,497	2,658,276	77,937,772	79,569,387
1924	58,105,921	29,939,429	4,194,811	92,240,161	99,040,427
1925	63,895,104	35,664,427	4,509,810	104,069,341	101,428,272
1926	64,978,458	43,968,335	4,952,334	113,899,127	105,982,730
1927	77,232,917	47,885,717	5,144,799	130,263,433	128,758,463
1928	93,531,487	50,597,969	3,948,452	148,077,908	145,837,547
1929	92,816,794	43,543,570	3,660,387	140,020,751	136,331,499
1930	108,008,062	35,212,793	2,600,800	145,821,655	150,588,913
1931	111,989,850	21,974,230	952,772	134,916,852	141,374,626
1932	87,165,260	10,046,915	350,775	97,562,950	90,806,306
1933	40,097,069	8,066,587	229,350	48,393,006	57,984,119
Totals	1,094,148,188	436,920,694	43,447,636	1,574,516,518	

*Includes all years previous to 1910.

†Figures for concrete yardage actually built not available prior to 1923.



ROADS, STREETS AND ALLEYS

State	Total Mileage All Roads	Mileage State System 1933	Miles of Federal Aid Roads Completed and Final Payment Made as of June 30, 1933	Total Mileage* of Concrete Roads to Jan. 1, 1934
Alabama	74,011	6,500	2,344.3	953
Arizona	23,238	2,895	1,270.4	443
Arkansas	74,178	8,900	1,932.8	1,018
California	77,085	14,063	2,500.1	5,508
Colorado	72,338	9,236	1,863.7	476
Connecticut	12,031	2,483	296.8	809
Delaware	3,834	1,141	381.1	724
Florida	29,761	10,902	661.1	707
Georgia	113,196	8,286	3,238.8	1,642
Idaho	40,610	4,802	1,592.4	64
Illinois	97,157	13,811	3,110.9	11,825
Indiana	77,627	8,378	2,109.4	5,241
Iowa	103,058	7,842	3,540.0	4,501
Kansas	133,154	9,310	4,052.9	1,199
Kentucky	62,187	7,322	1,933.6	1,013
Louisiana	38,041	17,631	1,619.6	1,865
Maine	20,287	2,368	823.0	280
Maryland	14,907	3,772	872.7	2,110
Massachusetts	18,770	1,809	875.9	580
Michigan	86,054	8,843	2,339.2	6,759
Minnesota	116,075	11,114	4,309.6	2,676
Mississippi	60,367	6,133	1,863.8	654
Missouri	106,047	16,260	3,233.2	4,007
Montana	69,398	5,013	2,973.2	36
Nebraska	94,739	7,825	4,259.7	785
Nevada	23,640	4,007	1,352.1	47
New Hampshire	13,014	3,083	448.0	256
New Jersey	19,803	3,420	637.9	1,959
New Mexico	33,145	10,373	2,300.9	107
New York	84,998	13,947	3,516.6	8,620
North Carolina	55,125	10,368	2,358.8	2,810
North Dakota	106,842	7,591	5,432.1	27
Ohio	85,326	11,839	3,057.9	4,352
Oklahoma	107,921	7,162	2,502.2	2,031
Oregon	44,007	4,737	1,630.5	370
Pennsylvania	110,326	34,020	3,276.8	6,473
Rhode Island	3,063	1,086	271.7	229
South Carolina	64,021	5,954	1,962.5	1,956
South Dakota	119,888	6,000	4,305.3	214
Tennessee	69,590	7,226	1,723.5	1,443
Texas	219,196	19,175	8,113.8	4,362
Utah	23,711	4,624	1,286.3	330
Vermont	14,040	1,028	393.8	283
Virginia	46,613	8,971	1,994.3	1,186
Washington	45,182	3,553	1,330.7	1,917
West Virginia	34,869	4,372	925.6	1,331
Wisconsin	82,979	10,104	2,760.1	4,945
Wyoming	39,805	3,389	2,179.8	13
TOTALS	3,065,254	382,668	107,759.4	101,136

*Mileage based on square yards of completed pavement 18 feet wide.

OF THE UNITED STATES

Motor Vehicle Registra- tion 1933	Motor Vehicles per Mile of Concrete Road	Concrete Streets Equivalent Mileage 30 Ft. Wide Total to Jan. 1, 1934	Concrete Alleys Equivalent Mileage 18 Ft. Wide Total to Jan. 1, 1934	State
206,361	217	414	69	Alabama
89,496	202	53	7	Arizona
188,242	185	374	6	Arkansas
1,958,807	356	3,052	175	California
266,491	560	105	221	Colorado
314,751	389	155	3	Connecticut
51,099	71	18		Delaware
279,265	395	349	85	Florida
330,147	201	199 562	34	Georgia
96,255	1,504	27	2	Idaho
1,463,050	124	2,885	976	Illinois
770,071	147	700	165	Indiana
632,292	140	1,048	132	Iowa
517,987	432	371	69	Kansas
294,547	291	208	65	Kentucky
232,688	125	309	43	Louisiana
168,173	600	60	5	Maine
313,274	148	230	171	Maryland
789,788	1,361	340	2	Massachusetts
1,077,209	159	970	542	Michigan
679,243	264	457	117	Minnesota
164,688	252	149	22	Mississippi
698,362	174	940	168	Missouri
110,245	3,062	54	10	Montana
390,651	498	190	48	Nebraska
28,324	708	18	5	Nevada
107,631	420	45	5	New Hampshire
845,734	432	1,296	16	New Jersey
76,643	716	58	4	New Mexico
2,240,757	260	2,003	14	New York
382,308	136	285	18	North Carolina
153,889	5,699	59	6	North Dakota
1,554,314	357	902	133	Ohio
451,712	222	621	34	Oklahoma
239,410	647	391	15	Oregon
1,635,019	253	1,019	114	Pennsylvania
136,261	595	22	1	Rhode Island
162,735	83	142	15	South Carolina
169,249	791	140	6	South Dakota
312,180	216	298	49	Tennessee
1,201,762	276	660	77	Texas
100,362	304	103	4	Utah
73,576	260	86	2	Vermont
344,704	291	159	15	Virginia
427,406	223	879	55	Washington
226,985	171	176	18	West Virginia
670,797	136	1,240	295	Wisconsin
52,560	4,043	34	2	Wyoming
23,677,500	234 (Av.)	24,223 24,686	4,040	TOTALS

FEDERAL AID FOR HIGHWAYS

FEDERAL Aid for roads has not only provided the incentive for state highway construction but it has also been of immense value in keeping road building activities under efficient state control. It has been responsible for a national coordinated highway system unequalled in any other country. Its extensive benefits have far exceeded in value the funds expended.

The Federal Aid Road Act, approved July 11, 1916, provided \$75,000,000 to be made available in five annual installments beginning with the fiscal year 1917. In February, 1919, provision was made for expenditure of an additional \$200,000,000, both sums to be used up by 1922.

This and subsequent legislation have made available the following sums for the fiscal years shown.

1917	\$ 5,000,000	1928	\$75,000,000
1918	10,000,000	1929	75,000,000
1919	65,000,000	1930	75,000,000
1920	95,000,000	1931	125,000,000
1921	100,000,000	2 1932	125,000,000
1922	75,000,000	3 1933	109,159,256
1923	50,000,000	4 1934	0
1924	65,000,000	4 1935	0
1925	75,000,000	1936	125,000,000
1926	75,000,000	1937	125,000,000
1927	75,000,000		

¹ Due to inability of many states to match Federal Aid and thereby secure benefits of funds authorized, a loan of \$80,000,000 was made and allotted to the various states. This amount is in addition to regular Federal Aid shown in above table. Provision was made for repayment in five annual installments by deductions from regular Federal Aid commencing with fiscal year 1933.

² In addition to the regular Fed-

eral Aid shown, there was made available, by the Emergency Relief and Construction Act of July 21, 1932, the sum of \$120,000,000 as a temporary advance to states to be repaid by deductions from future authorizations for regular Federal Aid. Provision was made for repayment over a period of 10 years commencing with the fiscal year 1938.

³ From regular Federal Aid for the fiscal year 1933 there was deducted the first installment for repayment of the \$80,000,000 loan.

⁴ The fiscal year 1933 ended with no definite provision made for the continuance of Federal Aid road construction. In place of the regular authorization, provision was made in the National Industrial Recovery Act, June 16, 1933, for highway construction as a means of unemployment relief during the fiscal year 1934. By this act there was made available \$400,000,000 to be expended on Federal Aid roads and extensions into and through municipalities and also on secondary and feeder roads in all states.

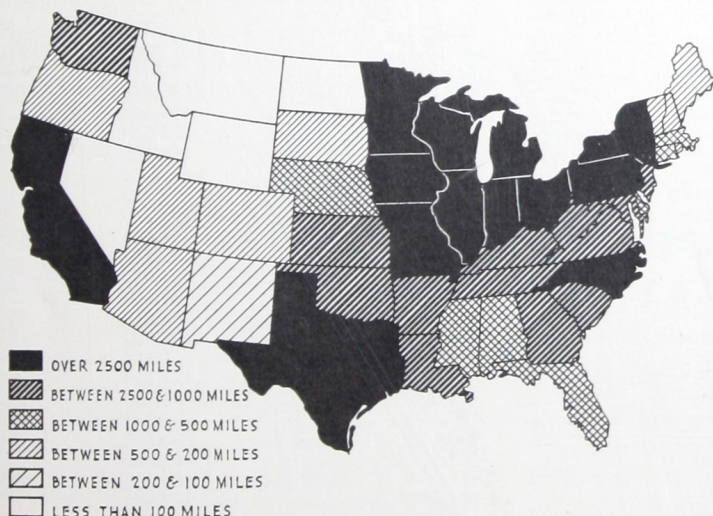
On June 18, 1934, an act was approved (H R 8781) known as the Hayden-Cartwright Bill. This made immediately available \$200,000,000 and further provided for continuation of regular Federal Aid in the fiscal years 1936 and 1937 by authorizing appropriation of \$125,000,000 in each of the two years. Section 14 of this act cancels repayments of previous loans. The full amount of the sums authorized will, therefore, be made available to the states without deduction.

Mileage of Improved Federal Aid Roads in U. S., by Types of Construction, as of June 30, 1933

(Figures from U. S. Bureau of Public Roads)

	Miles	Per Cent of Total Mileage
Concrete	37,565	34.9
Bituminous Concrete	3,972	3.7
Bituminous Macadam	4,627	4.3
Low Cost Bituminous Mix	5,650	5.2
Macadam (Treated)	1,123	1.1
Macadam (Untreated)	2,026	1.9
Gravel (Treated)	1,113	1.0
Gravel (Untreated)	31,117	28.8
Sand-Clay (Treated)	80	0.1
Sand-Clay (Untreated)	7,111	6.6
Graded and Drained	11,777	10.9
Miscellaneous (Block Types, etc.)	1,056	1.0
Bridges and Approaches	542	0.5
Total	107,759	100.0

CONCRETE ROADS IN UNITED STATES—JANUARY 1, 1934



Concrete Street Pavements Awarded in the 95 Cities of the United States With Population Over 100,000

(December 31, 1933)

FIVE CITIES WITH POPULATION OVER 1,000,000

Cities	Square Yards of Concrete Street Pavement			
	Awarded Prior to 1933	Awarded During 1933	Total to Dec. 31, 1933	Equivalent Miles 30-Ft. Pavement
Chicago	8,113,074	415,278	8,528,352	484.5
Detroit	1,527,298		1,527,298	86.8
Los Angeles	22,824,611	235,848	23,060,459	1,310.3
New York	1,409,486	21,380	1,430,866	81.3
Philadelphia	1,008,831	52,700	1,061,531	60.3
Total	34,883,300	725,206	35,608,506	2,023.2

EIGHT CITIES WITH POPULATION BETWEEN 500,000 AND 1,000,000

Baltimore	2,745,330	5,735	2,751,065	156.3
Boston	309,530	3,115	312,645	17.8
Buffalo	353,559		353,559	20.1
Cleveland	202,865		202,865	11.5
Milwaukee	3,755,830	9,930	3,765,760	214.0
Pittsburgh	666,902	64,565	731,467	41.6
San Francisco	1,034,413	36,916	1,071,329	60.8
St. Louis	1,575,929	27,275	1,603,204	91.1
Total	10,644,358	147,536	10,791,894	613.2

TWENTY-FIVE CITIES WITH POPULATION BETWEEN 250,000 AND 500,000

Akron	230,972		230,972	13.1
Atlanta	3,693,381	3,750	3,697,131	210.1
Birmingham	1,717,503	1,275	1,718,778	97.6
Cincinnati	2,602,643	23,576	2,626,219	149.2
Columbus	455,191		455,191	25.9
Dallas	916,803	17,241	934,044	53.1
Denver	174,109	19,180	193,289	11.0
Houston				
Indianapolis	1,396,361	98,634	1,494,995	84.9
Jersey City	105,228		105,228	6.0
Kansas City	4,389,513	62,592	4,452,105	253.0
Louisville	117,842		117,842	6.7
Memphis	453,242	11,085	464,327	26.4
Minneapolis	418,604	5,005	423,609	24.1
Newark	237,418		237,418	13.5
New Orleans	788,731	115,660	904,391	51.4
Oakland	511,865		511,865	29.1
Portland, Ore.	3,335,566	87,300	3,422,866	194.5
Providence	31,595		31,595	1.8
Rochester	398,356		398,356	22.6
St. Paul	989,459	3,733	993,192	56.4
San Antonio	453,527		453,527	25.8
Seattle	8,431,092	12,702	8,443,794	479.8
Toledo	1,102,481		1,102,481	62.6
Washington	3,177,388	296,935	3,474,323	197.4
Total	36,128,870	758,668	36,887,538	2,096.0

FIFTY-SEVEN CITIES WITH POPULATION BETWEEN 100,000 AND 250,000

	Prior to 1933	During 1933	Total Dec. 31, 1933	Equiv. Miles 30-Ft. Pvmt.
Albany	793,244	2,840	796,084	45.2
Allentown	358,927	4,373	363,300	20.6
Bridgeport	4,900		4,900	0.3
Cambridge	48,716		48,716	2.8
Camden	305,729		305,729	17.4
Canton	10,000		10,000	0.6
Chattanooga	308,625	6,000	314,625	17.9
Dayton	729,607	14,931	744,538	42.3
Des Moines	998,032	43,049	1,041,081	59.1
Duluth	1,328,459	144,305	1,472,764	83.7
Elizabeth	382,941		382,941	21.7
El Paso	44,765		44,765	2.5
Erie	86,993	8,748	95,741	5.4
Evansville	24,380		24,380	1.4
Fall River	100,834		100,834	5.7
Flint	111,881		111,881	6.3
Ft. Wayne	190,396	715	191,111	10.9
Ft. Worth	163,522		163,522	9.3
Gary	650,042		650,042	36.9
Grand Rapids	670,760		670,760	38.1
Hartford	132,022		132,022	7.5
Jacksonville	333,130	99,393	432,523	24.6
Kansas City, Kan.	1,128,851	12,200	1,141,051	64.8
Knoxville	301,000	33,487	334,487	19.0
Long Beach	2,104,492	198	2,104,690	119.6
Lowell	128,676		128,676	7.3
Lynn	82,225		82,225	4.7
Miami	300,194	57,483	357,677	20.3
Nashville	3,000	1,500	4,500	0.3
New Bedford	15,372		15,372	0.9
New Haven	347,445		347,445	19.7
Norfolk	291,000	4,000	295,000	16.8
Oklahoma City	1,303,464	13,114	1,316,578	74.8
Omaha	229,474		229,474	13.0
Paterson	204,705	2,500	207,205	11.8
Peoria	883,656	20,784	904,440	51.4
Reading	136,088	10,809	146,897	8.3
Richmond	312,638	6,100	318,738	18.1
Salt Lake City	513,586		513,586	29.2
San Diego	3,614,151	9,134	3,623,285	206.0
Scranton	23,140	900	24,040	1.4
Somerville, Mass.	40,673		40,673	2.3
South Bend	407,929		407,929	23.2
Spokane	580,635	19,124	599,759	34.1
Springfield, Mass.	128,330	2,744	131,074	7.4
Syracuse	196,364	2,900	199,264	11.3
Tacoma	1,190,952	17,306	1,208,258	68.6
Tampa	34,219	17,166	51,385	2.9
Trenton	689,672	7,873	697,545	39.6
Tulsa	1,501,729	21,562	1,523,291	86.5
Utica	203,198		203,198	11.5
Waterbury	5,890	350	6,240	0.4
Wichita	1,407,543	7,370	1,414,913	80.4
Wilmington, Del.	121,406	3,417	124,823	7.1
Worcester	210,870	7,206	218,076	12.4
Yonkers	297,027		297,027	16.9
Youngstown	811,960		811,960	46.1
Total	27,529,459	603,581	28,133,040	1,598.3
Totals, 95 cities	109,185,987	2,234,991	111,420,978	6,330.7

EARLY CONCRETE PAVEMENTS

Scotland

- 1865 Inverness—Road to Freight Station.
- 1866 Edinburgh—Approach to George IV Bridge.
- 1872 Edinburgh—Liven Terrace.
- 1872 Edinburgh—Gillespie Crescent.
- 1872 Edinburgh—Glengyle Terrace.
- In the 70's—Edinburgh Livingstone Place.
- In the 70's—Edinburgh Argyle Park Terrace.

The oldest concrete pavements known to be in service are on Liven Terrace, Glengyle Terrace and Gillespie Crescent, Edinburgh, Scotland, and were built in 1872. They are more than 62 years old and still carry traffic.

France

- 1876 Grenoble—36 streets, many still in use.

United States

- 1892 Bellefontaine, Ohio—West side of Main Street, a strip 10 feet wide, 220 feet long.
- 1893-4 Bellefontaine, Ohio—Remainder of Main Street, also Columbus, Opera and Court Streets were paved, being the four sides of the Public Square.
- 1894 Watertown, N. Y.—Lane leading to station.
- 1896 Richmond, Ind.—Alley.
- 1896-1906 Richmond, Ind.—Streets and alleys.
- 1899 Detroit, Mich.—Orchestra Place (Woodward Avenue to John R. St.)
- 1904 Grand Rapids, Mich.—Quigley Blvd.

- 1904 LeMars, Iowa—Street.
- 1904 Mobile, Ala.—St. Francis Street.
- 1905 Manchester, N. H.—Alley.
- 1907 Chicago, Illinois—21st, 22nd St. and 21st Place.
- 1907 New Haven, Conn.—East Chapel Street.
- 1907 Salt Lake City, Utah—"B" Street (S. Temple to N. Temple Street.)
- 1908 Chicago, Illinois—Ohio Street.
- 1908 Chicago, Illinois—Center and Emerald Avenue.
- 1908 Billings, Mont.—Yellowstone Avenue, Division Street.
- 1908 Nazareth, Pa.
- 1908 New Brunswick, N. J.
- 1909 Los Angeles Co., California.
- 1909 Waukegan, Illinois—Clayton St.
- 1910 Wayne Co., Mich.—Wayne Road South.

At the beginning of 1909 the United States had the following quantities of concrete pavement:

Roads	34,061 square yards.
Streets	444,864 square yards.
Alleys	112,491 square yards.

Total 591,416 square yards.

1892 saw the first concrete pavement constructed in the United States in Bellefontaine, Ohio. This was a narrow strip along the hitching rack on one side of the Court House Square. The following year the rest of the street was paved as well as the three other streets around the Court House. All of this pavement is giving perfect service today, although more than 42 years old.

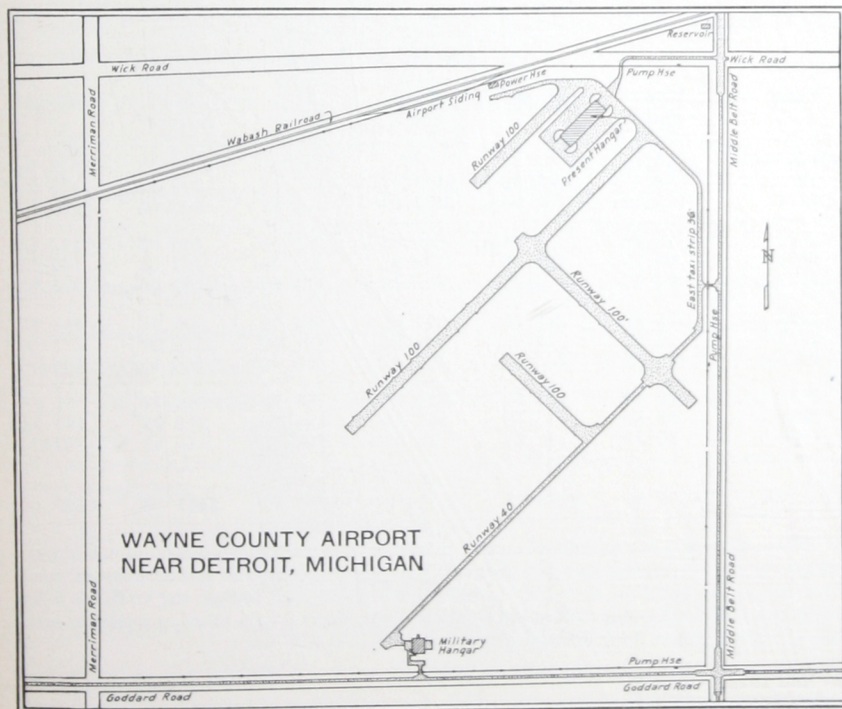
Steep Grades Are Concrete Paved in Many States

State	Location	Street or Road	Grade—Per Cent	State	Location	Street or Road	Grade—Per Cent
Ala.	Birmingham	Eula Street	19	Mo.	Kansas City	22nd Street	18
Ark.	Fayetteville	School Street	10-12	N. J.	Paterson	Jefferson St.	21
Calif.	Los Angeles	Ewing Street	25-32	N. M.	Gallup	Green Street	20
Colo.	Boulder	Mapleton Ave.	15	N. Y.	Ossining	Ellis Place	21
Conn.	Near E. Berlin	East Berlin Rd.	10	N. C.	Asheville	Maxwell, Blanton, Eagle and Victoria Streets	7-12
Ga.	Macon	New Street	15	Ohio	Cambridge	South 7th St.	19
Ill.	Savanna	Walnut Street	23	Penn.	Altoona	Seventeenth St.	27
Iowa	Council Bluffs	Fifteenth Ave.	17	Texas	El Paso	Laurel Street	17
Ky.	Lexington	S. Upper Street	10.5	Va.	Appalachia	Virginia Ave.	24
Md.	Baltimore	Fairmount Rd.	16	Wash.	Seattle	36th Ave. N.	26.6
Mich.	Milford	G.M.C. Proving Ground	11.2	W. Va.	Bluefield	Mercer Street	28.2
Minn.	Duluth	22nd Ave. W.	17.43	Wis.	Milwaukee	Nineteenth St.	15.3
Miss.	Vicksburg	China Street	18.5				

Some Airports With Concrete Runways and Aprons

Location	Field	Concrete Runways Sq. Yd.	Concrete Aprons, Taxiways and Drive- ways—Sq. Yd.
Riverside, Calif.	March (USA)		48,700
San Diego, Calif.	No. Island (USN)		46,800
E. St. Louis, Ill.	Curtiss	53,000	22,000
Indianapolis, Ind.	Mars Hill	55,100	20,000
Kansas City, Kan.	Fairfax		74,800
Shreveport, La.	Barksdale (USA)	173,200*	
Detroit, Mich.	Municipal	25,000	20,400
Dearborn, Mich.	Ford	48,000	18,100
Wayne Co., Mich.	County	110,900	83,300
Mt. Clemens, Mich.	Selfridge (USA)	28,800	26,000
St. Paul, Minn.	Municipal	4,300	18,500
Kansas City, Mo.	Municipal		20,000
St. Louis, Mo.	Municipal	5,000	38,200
Buffalo, N. Y.	Municipal		25,800
New York, N. Y.	Floyd Bennett	78,700	69,600
New York, N. Y.	Roosevelt		54,500
New York, N. Y.	Mitchell (USA)	30,000	32,000
Valley Stream, N. Y.	Curtiss		24,000
Cincinnati, Ohio	Municipal	86,000	12,600
Cleveland, Ohio	Municipal		27,800
Warwick, R. I.	Hillsgrove	174,000*	
Milwaukee, Wis.	County		281,000

*Includes Aprons.



ROAD MAINTENANCE COSTS

PROGRESSIVE states and counties now keep itemized road upkeep cost figures that they may know how each dollar is allocated for surface repair, weed cutting, snow removal, etc. This record, together with traffic counts, enables the states to determine the cost of road upkeep per vehicle for each type of surface.

Records of this type become more valuable to these states each year in determining the economy of future construction.

The following tabulations show the importance of these records. Concrete pavements not only carry more traffic than other types of surfaces but are the most economical over a period of years.

Illinois Maintenance Costs Per Mile Per Year For Various Types of Road-Wearing Surfaces

(Compiled from Reports of the Illinois Division of Highways)

Figures indicate maintenance costs per mile per year for wearing surface only on the State Maintenance System. Concrete constituted 10,617.3 miles of the 11,234.1 miles of improved roads.

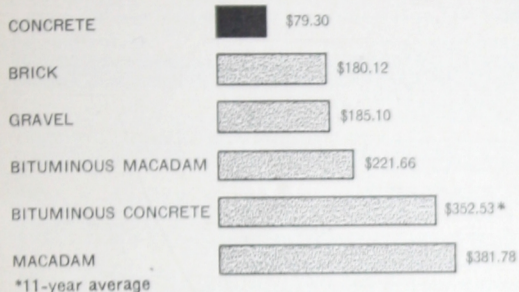
Year	Concrete	Brick	Bituminous Concrete	Bituminous Macadam*	Water-bound Macadam*	Gravel*
1921 & 1922	\$ 68.24	\$ 62.36	(1)	\$129.36	\$987.52	\$152.02
1923	73.47	88.86	\$109.47	143.97	302.37	149.39
1924	122.12	151.97	437.89	162.07	405.06	173.92
1925	72.20	123.41	246.34	209.39	146.78	132.84
1926	65.15	163.34	570.98	254.29	127.63	242.74
1927	72.79	168.27	511.44	201.63	1,039.05	271.06
1928	72.29	184.56	207.84	430.99	405.42	313.35
1929	69.66	226.92	900.88	137.90	373.97	271.26
1930	108.40	205.52	173.42	562.48	356.95	150.85
1931	90.02	322.81	184.56	63.41	310.17	151.34
1932	82.38	224.76	107.25	158.96	370.95	167.64
1933	59.37	130.03	38.92	258.37	150.63	69.52
(2)						
13-yr. av.	\$ 79.30	\$180.12	\$352.53	\$221.66	\$381.78	\$185.10

*"Note: The costs per mile shown under bituminous macadam, waterbound macadam, and gravel do not represent a fair average cost for maintenance and upkeep of such types due to the fact that they are located on State Aid roads where the traffic is light and only a sufficient amount of maintenance is expended to keep them in passable condition."—(Statement from Annual Reports.)

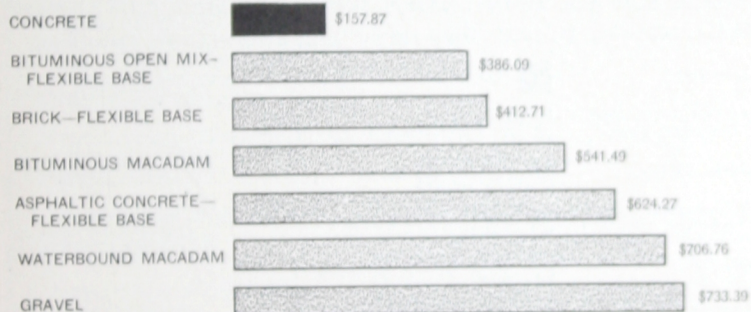
(1) None on state system in 1921 and 1922.

(2) 11-year average.

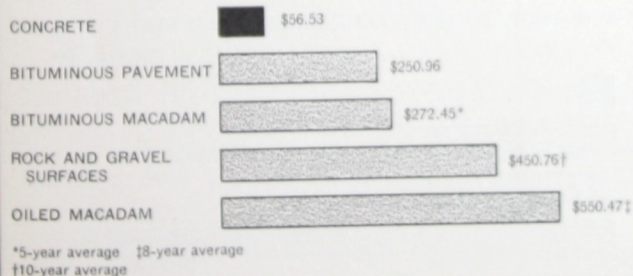
AVERAGE SURFACE MAINTENANCE COSTS PER MILE FOR 13 YEARS
1921-1933 inclusive—Reported by Illinois Division of Highways



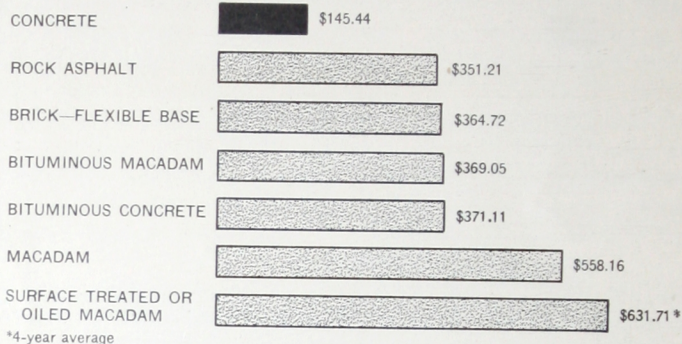
AVERAGE SURFACE MAINTENANCE COSTS PER MILE FOR 6 YEARS
1928-1933 inclusive—Reported by New York Division of Highways



AVERAGE SURFACE MAINTENANCE COSTS PER MILE FOR 11 YEARS
1923-1933 inclusive—Reported by Oregon State Highway Department

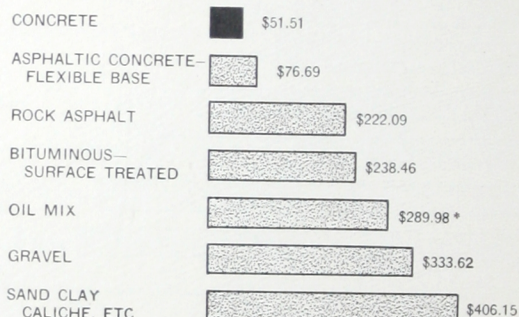


AVERAGE SURFACE MAINTENANCE COSTS PER MILE FOR 9 YEARS
 1925-1933 inclusive—Reported by Ohio Dept. of Highways and Public Works



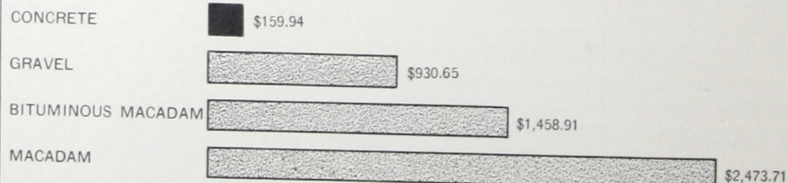
*4-year average

AVERAGE SURFACE MAINTENANCE COSTS PER MILE FOR 3 YEARS
 Sept. 1, 1929-Aug. 31, 1932—Reported by Texas State Highway Department

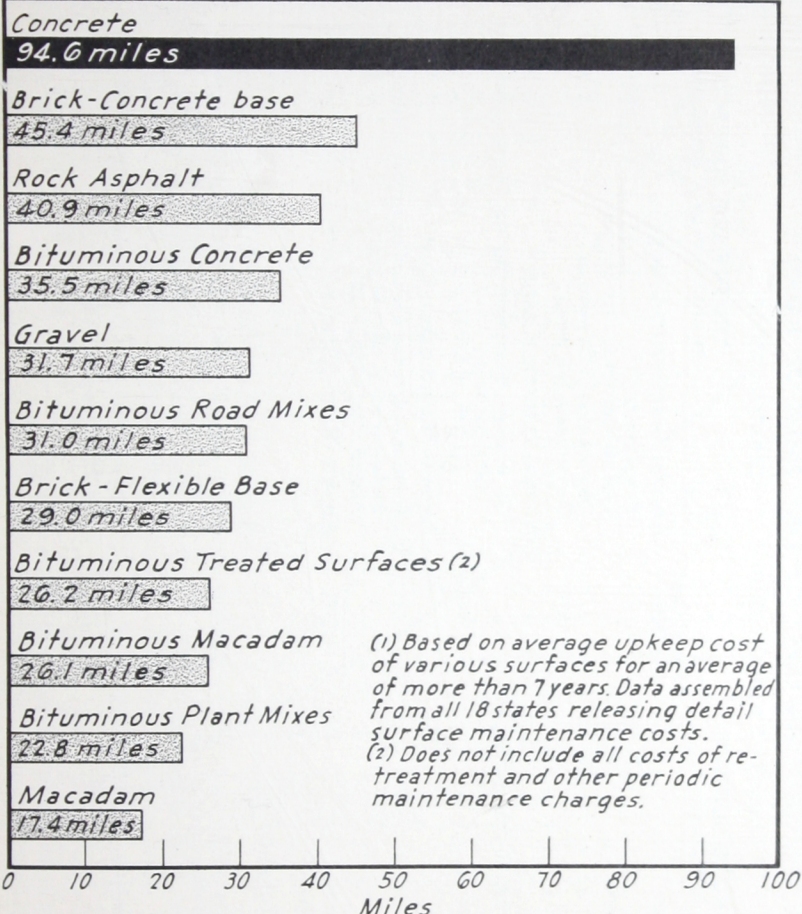


*2-year average

AVERAGE SURFACE MAINTENANCE COSTS PER MILE FOR 5 YEARS
 1929-1933 inclusive—Reported by New Jersey State Highway Department



MILES OF ROAD SURFACE MAINTAINED FOR ONE YEAR WITH \$10,000 ⁽¹⁾



The above chart includes road surface maintenance costs of those 18 states that release such figures.

Records cover periods ranging from 3 to 14 years for the various states. Bituminous surfaces noted have flexible bases.

Records show that concrete sur-

faces have the lowest maintenance cost, while carrying the heaviest travel, averaging over one thousand cars per day. Should light traffic surfaces carry the same traffic as concrete, even for a short period, surface maintenance costs of these types would be increased materially.

THE REAL COST OF ONE MILE OF ROAD

Based on a study made in a representative state

CONCRETE ROAD SURFACE

Heavy duty design

CONCRETE ROAD SURFACE		TEMPORARY SURFACE	
Heavy duty design		On existing stone or gravel base	
Annual Investment Charge	Annual Cost Per Mile	Annual Investment Charge	Annual Cost Per Mile
First Cost	\$21,418*	First Cost	\$11,886*
Less salvage value after 20 years	10,709	Less salvage value after 20 years	5,943
Depreciation in 20 years	\$10,709	Depreciation in 20 years	\$ 5,943
Depreciation per year		Depreciation per year	\$ 297
Annual Interest Charge		Annual Interest Charge	
On average investment during 20-year period at 4.0% per year.		On average investment during 20-year period at 4.0% per year.	
(21,418 + 10,709) ÷ 2 × .04	642	(11,886 + 5,943) ÷ 2 × .04	357
Annual Maintenance Cost		Annual Maintenance Cost	
Includes all maintenance	137*	Routine maintenance including surface treatments	569*
		Surface renewal after 10 years	\$ 4,903*
Annual Road Surface Cost	\$ 1,314	Annual Road Surface Cost	\$ 1,568
Generally paid from motor taxes.			

Annual Cost of Vehicle Operation

Cost of gasoline, oil, tires, etc.

5.5c per mile × 892† cars daily × 365 days

(5.5c per mile cost of operating average car on concrete, reported by Iowa State College and Highway Research Board.)

\$17,907

Annual Cost of Transportation or Real Cost of Highway Surface

\$19,221

Saving per Mile in Annual Road Costs with Concrete

Saving per Mile in Annual Cost of Vehicle Operation with Concrete

Total Annual Saving per Mile in Real Cost of Highways with Concrete

\$ 254

2,442

\$2,696

Annual Cost of Vehicle Operation

6.25c per mile × 892† cars daily × 365 days

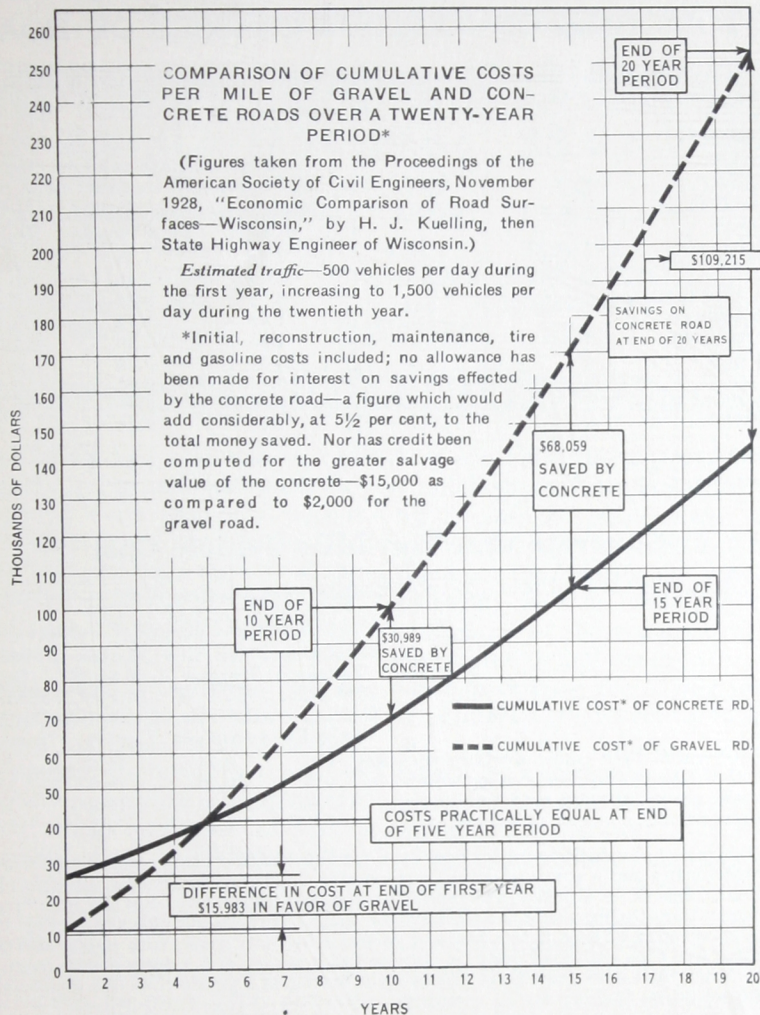
(6.25c per mile cost of operating average car on intermediate type roads, reported by Iowa State College and the Highway Research Board.)

\$20,349

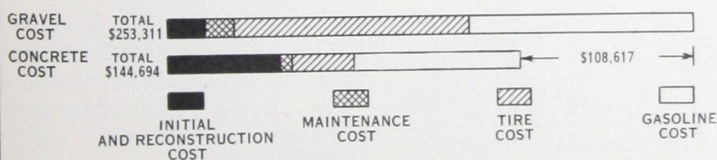
Annual Cost of Transportation or Real Cost of Highway Surface

\$21,917

*Actual cost figures. †Average traffic carried—concrete 1696 vehicles; temporary surface 892 vehicles. Savings computed on basis of 892 vehicles for both types to permit comparison.



ANALYSIS OF TOTAL COSTS AT END OF 20 YEARS



RELATIVE COST OF OPERATING AN "AVERAGE" AUTOMOBILE ON VARIOUS CLASSES OF ROADS

(From Bulletin 91, Engineering Experiment Station, Iowa State College, Compiled by T. R. Agg and B. S. Carter)

Item of Cost	Approximate relative cost of operation in cents per mile		
	High Type Roads	Intermediate Type Roads	Low Type Roads
Gasoline	1.09	1.31	1.61
Oil	0.22	0.22	0.22
Tires and tubes	0.29	0.64	0.84
Maintenance	1.43	1.72	2.11
Depreciation	1.26	1.39	1.57
License	0.14	0.14	0.14
Garage at \$4 per month	0.44	0.44	0.44
Interest at 6 per cent	0.36	0.36	0.36
Insurance	0.21	0.21	0.21
Total cost	5.44	6.43	7.50
Relative cost	1.00	1.18	1.38

Concrete and Ton-Mile Vehicle Cost

(Data from Iowa State College Engineering Experiment Station)

	Type and Speed of Vehicle			
	Solid tire Trucks 10M.P.H.	Pneu. tire Trucks 15M.P.H.	Autos 25 to 35 M.P.H.	Motor Buses 25M.P.H.
	Cents per ton-mile	Cents per ton-mile	Cents per mile	Cents per bus-mile
Ordinary earth, light traffic, average condition	9.5	9.95	12.6	29.6
Best earth, packed by use, average condition	9.2	9.50	12.0	27.8
Ordinary gravel, average condition	9.0	9.40	11.8	27.8
Portland cement concrete pavement	7.75	7.70	9.3	22.5

Average cost of vehicle operation over each type of road in cents per mile, as determined by experiments and a study of actual cost records. Trucks vary greatly in weight; consequently, figures for trucks are in terms of ton-miles. To get total cost per mile for any truck, multiply the figures in the table by the weight of the truck plus the average load. From this it may be seen that a loaded two-and-a-half-ton truck, with pneumatic tires, weighing five tons with load, may be operated at a saving of 8.5 cents a mile over concrete rather than over gravel. At this rate the saving in a year's time, for a mileage of 20,000 would be \$1,700.

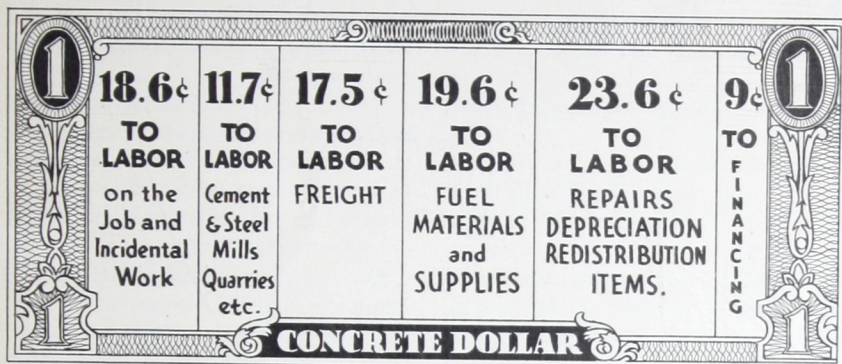
Ton-Miles per Gallon on Different Surfaces

Fuel economy was the subject of a study made by the Iowa State College Experiment Station, at Ames, Iowa, under the direction of Prof. T. R. Agg and Prof. W. L. Foster. In this case the summary is given in terms of ton-miles per gallon of gasoline, a heavy aviation

army truck being used with a gross load of 8 tons and net load of 3.5 tons.

Road Type	Ton-miles per gallon
Concrete	30.6
Brick, monolithic	29.7
Bitulithic	23.4
Gravel	21.2

LABOR GETS 91 CENTS OF THE CONCRETE ROAD DOLLAR



THIS chart reveals that workers get directly and indirectly but altogether quite promptly, all but a few cents of the road dollar. The chart is based on a survey of employment costs in concrete road building made by the U. S. Bureau of Public Roads.

How labor is benefited may be judged by the fact that two trainloads of materials, of 50 cars each, are needed to build one mile of concrete pavement. These materials, of which only a fifth or a sixth is cement, must be mined or quarried, manufactured or processed, and transported to the site of the new road.

Of each \$1,000 received by the contractor, he pays \$186 directly to men on the road job and incidental workers.

Of the remaining \$814, labor receives \$724 through mills, quarries, sand, gravel and crushed stone plants, equipment makers, railroads, fuel producers and so on.

Since 75 to 100 per cent of the materials actually going into the road are locally produced, the bene-

fit to local labor is large and direct.

The high return to labor is credited by Thomas H. MacDonald, chief of the Bureau, "to the fact that there are no intrinsically valuable materials used in road building."

Because of the requirement for raw materials and the need for such large quantities, few if any industries offer so great a return to labor as road construction. And the return is widespread—not purely local—to the benefit of workers in many industries over wide areas.

For these reasons, highway construction was made a major outlet for PWA funds in the battle against unemployment. Because of pressing highway needs and the ability to quickly draft plans, state highway departments were able to keep more men at work for much of the time than were employed in all other types of PWA construction.

Aside from improving road surfaces, supplementary structures, such as rail-highway grade separations, highway grade separations and bridges also require workers in large numbers.

DIVERSION OF MOTOR TAXES

IN the last seven years a total of \$445,000,000 of license fee and gas tax money has been diverted from state highway construction and used for general government purposes.

Beyond that, counties diverted a total of \$105,000,000 during 1932, 1933 and 1934 from refunds of state motor taxes.

Therefore, during the seven-year period, \$550,000,000 of the money paid in by motorists through taxes expressly designed for better and safer highways was not used for that purpose.

This diverted money came directly out of funds available for new construction. Before money can be allocated to new work, large, unavoidable outlays must be made to meet administrative costs, financing and other fixed charges and repair and servicing of roads already built.

In terms of construction, all this diversion deprived the country of some 10,000 rail-highway grade separations or more than 20,000 miles of first class roads.

The estimated diversion in 1934 of \$135,000,000 from state construction funds and of \$40,000,000 from local funds, meant the loss of the equivalent of 400,000 jobs, or support for 1,200,000 people.

Diversion is made more serious by the current trend to reduce motor taxes, in many states with conspicuous disregard for road needs. Falling motor tax revenues through tax reduction, coupled with diversion, has placed several states in the position of having little or no money for new state construc-

tion. In fact, some states apparently will be unable to meet present and near-future Federal Aid road requirements.

While the Federal Government and many states look to highways as a major means of providing jobs, those states in which diversion is practiced are in effect nullifying employment efforts.

During the last few years, actual results of highway construction, as measured in terms of new highways and safety structures, have been considerably less than before the depression; this despite the supreme attempt of the Federal Government to stimulate employment on highways.

As shown in the last few Congressional road hearings, there is a growing feeling that the states themselves should carry the brunt of highway construction. Recent Federal legislation portends an early return to the basis where states must match Federal road money dollar for dollar.

The Federal road appropriation bill of 1933 declares: "It is unfair and unjust to tax motor vehicle transportation unless the proceeds of such taxation are applied to the construction, improvement or maintenance of highways."

And then the statute further enacts that the states that divert any more motor tax money than was authorized by their laws when the bill was enacted may have their shares of Federal money reduced by as much as a third.

That diversion is definitely against the public welfare is shown by actual road and street needs.

Rail-highway grade separations, highway grade separations, elimination of curves, smoothing of roads and streets, and widening of congested roads and streets are all part of the gigantic job that faces the gas tax and license fee.

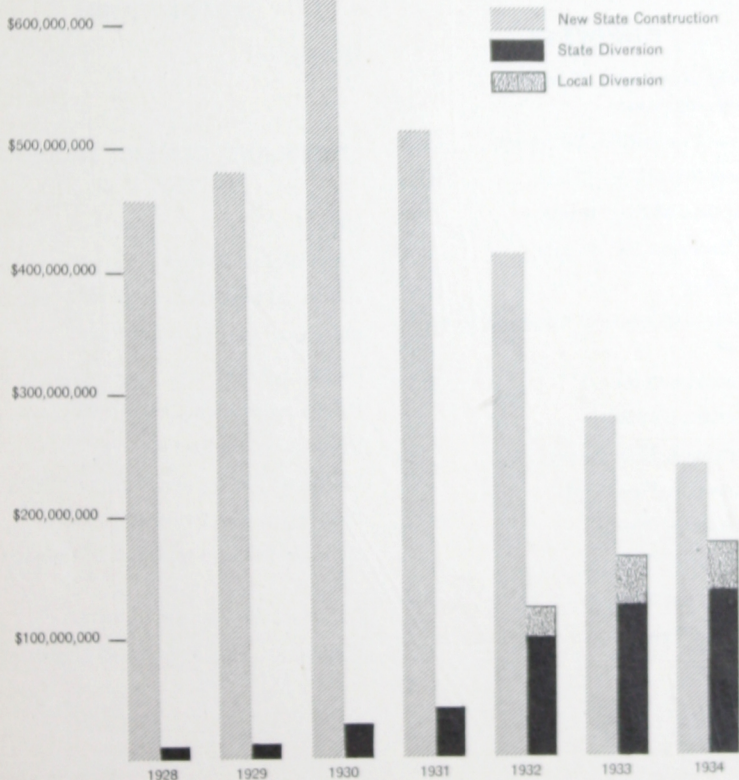
In regard to improvement of road surfaces, there is still much to do, according to the records. Here is shown the condition of the main state highways, which carry upwards of two-thirds of all rural

traffic. The table is based on improvement up to January 1, 1934.

Condition of Main State Highways

	Miles
High Class / (Concrete, brick, bituminous and other types with stable bases)	120,000
Intermediate Type (Surface-treated gravel, stone or macadam)	63,000
Mud or dust	200,000
Total, State Systems	383,000

DIVERSION OF STATE HIGHWAY FUNDS COMPARED WITH NEW STATE HIGHWAY CONSTRUCTION OUTLAYS



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